CONTRACT REPORT

No. AR/92/9

Post-emergence control of annual weeds, volunteer potatoes and oilseed rape in onions and leeks

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ADAS

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AUTHENTICATION

I declare that this work was done under my supervision according to the procedures described herein and that this report represents a true and accurate record of the results obtained.

..... C.S.Speller ..... Date ..... 7.1.93 .....

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Summary

Fourteen herbicide programmes were compared for their effectiveness in controlling potatoes, oilseed rape and other broad-leaved weeds in an onion crop (cv. Hysam) on a peaty loam soil at ADAS Arthur Rickwood in 1992.

The products evaluated in sequences or tank-mixes were Atlas Somon, Brasoran, Dow Shield, Fortrol, Gesagard, Starane 2, Totril and Tribunil. The programmes commenced at the early first true leaf stage of the crop and continued until its second true leaf stage. There were three applications (7, 15 and 22 May).

All programmes reduced the vigour of the potatoes. Oilseed rape was effectively controlled by all programmes except where Starane 2, alone or in a tank-mix with Dow Shield, was applied. Control of other broad-leaved weeds was good except where a repeated application of Gesagard was used.

All programmes reduced the vigour and marketable yield of the onions compared with the hand-weeded control. The two programmes which gave the most effective control of potatoes and oilseed rape, with minimum yield loss, included the use of non-approved products Dosaflo and Tribunil. The most effective programmes which used approved products comprised repeated applications of tank-mixes of either Starane 2 + Fortrol or Totril + Fortrol + Starane 2 followed by Starane 2 + Totril. Applications of Atlas Somon, tank-mixed with either Fortrol or Totril, proved both safe and effective at reducing early potato vigour, but weed control was not long-lasting.

Objective

To evaluate, in the field, a range of herbicides which are safe on onions and have the potential for removing volunteer potatoes, oilseed rape and later-emerging weeds.

Introduction

The problem of volunteer potatoes and oilseed rape in vegetable crops is on the increase and is particularly evident in weakly competitive crops such as onions. Normal broad-leaved weed herbicides such as Totril, Basagran, and Fortrol have some action against potatoes when used as single chemical applications, but this control is neither complete nor reliable. The use of Starane 2, the off-label approval for which was gained by the HDC in 1990, has increased the grower's choice of herbicides for potato control. Previous experiments in 1990 and 1991, at the ADAS Arthur Rickwood site, sought to determine how best to exploit Starane 2 in herbicide programmes during the early development stages of the crop. In those seasons, the safest and most effective time to use Starane 2 was from the second true leaf stage of the crop. In 1992, a range of tank-mixes of chemicals, including Starane 2, were evaluated for their efficacy against both potatoes and oilseed rape from the first true leaf stage of the onions. There were two experiments in 1992, one at ADAS Arthur Rickwood (reported here) and the other at HRI Kirton (reported separately).

Materials and Methods

Site

The experiment was conducted on Drain Ground field at ADAS Arthur Rickwood in Cambridgeshire. The soil type was a peaty loam (30-66 cm deep) with 23 % organic matter content overlaying sand and gravel (Adventurer's Shallow Series).

Treatments

Herbicide programmes

	First and second applications 7 and 15 May first true leaf	Third application 22 May second true leaf
1.	Untreated (control)	
2.	Hand-weeded (control)	
3.	Totril 0.5/0.7 l/ha	Totril 1.4 l/ha
4.	Totril 0.5/0.7 l/ha	Starane 2 1 l/ha
5.	Starane 2 0.2 l/ha	Starane 2 0.5 l/ha + Totril 0.5 l/ha
6.	Atlas Somon 20 kg/ha + Totril 0.25 l/ha	Starane 2 0.5 l/ha + Totril 0.5 l/ha
7.	Atlas Somon 10 kg/ha + Fortrol 0.25 l/ha	Starane 2 0.5 l/ha + Totril 0.5 l/ha
8.	Starane 2 0.2 l/ha + Totril 0.3 l/ha	Starane 2 0.5 l/ha + Totril 0.5 l/ha
9.	Starane 2 0.2 l/ha + Fortrol 0.3 l/ha	Starane 2 0.5 t/ha + Totril 0.5 l/ha
10.	Starane 2 0.2 l/ha + Dow Shield 0.2 l/ha	Starane 2 0.5 l/ha + Totril 0.5 l/ha
11.	Totril 0.3 l/ha + Fortrol 0.2 l/ha	Starane 2 0.5 l/ha + Totril 0.5 l/ha
12.	Totril 0.13 l/ha+ Fortrol 0.13 l/ha + Basagran 0.5 l/ha	Starane 2 0.5 l/ha + Totril 0.5 l/ha
13.	Totril 0.25 l/ha + Fortrol 0.25 l/ha + Starane 0.25 l/ha	Starane 2 0.5 l/ha + Totril 0.5 l/ha
14.	Gesagard 0.58 l/ha	Starane 2 0.5 l/ha + Totril 0.5 l/ha
15.	Tribunil 2 kg/ha	Starane 2 0.5 l/ha + Totril 0.5 l/ha
16.	Totril 0.5 l/ha	Dosaflo 3 l/ha

The first two treatment applications for 5-15 formed the basis of the contracted experiment.

Treatment 3 was the standard farm crop herbicide programme, treatment 4 was the best approved programme, and treatment 16 the best non-approved programme, from 1991.

Treatment application

All treatments were applied in 250 l/ha water using an Oxford Precision Sprayer with Lurmark 11003 nozzles at 2 bar pressure.

Husbandry

Onions (cv. Hysam) were drilled on 20 February 1992. On 10 March, potatoes (cv. Maris Piper) were planted by hand to achieve a uniform density of 30 plants per plot (approximately 3/m^2). The oilseed rape was sown on three occasions (1 April, 24 April and 19 May) to achieve a spread of maturity at the time of treatment application. On each occasion, the seed was sown as a 0.5 m band across the width of the bed of each plot. The crop received a standard pre-emergence and early post-emergence herbicide programme (Appendix I). The first herbicide treatments commenced at the first true leaf stage on 7 May. The second applications followed one week later on 15 May with the final applications on 22 May when the crop was at the second true leaf stage. The hand-weeded plots were hoed on 9 May. From 18 June, the crop received a standard herbicide programme. Apart from herbicides, the trial received normal commercial inputs. The trial was harvested on 1 September, at its 90% foliar fall over stage, dried in store, and graded and assessed for yield and quality on 28 September.

Assessments

The onions were counted (plants/m^2) on 27 April, before the treatments commenced, and at harvest. The vigour (0-10, where 0 = dead and 10 = healthy and vigorous) of the onions, potatoes and weeds were recorded on 6, 15 and 19 May, on 9 June and on 31 July. The number (plants/m^2) of oilseed rape plants was recorded on 6, 19 and 27 May.

The yields of onions in diameter size grades (under 25 mm, 25-40 mm, 40-50 mm 50-60 mm, and over 60 mm) were recorded after drying on 28 September, when the number of defective bulbs was recorded, and bulb quality assessed (E.C. grading standard).

Design and statistical analysis

The trial was a randomised block with three replicates. Each plot consisted of a 1.68 m bed and was 6 m in length (10.08 m^2) with four rows per bed at 350-250-350 mm spacing.

All the data were subjected to analyses of variance and angular-transformed where appropriate.

Results

Plant establishment

The onions were fully established on 27 April when there were, on average, 58 plants/m^2, similar for all plots. On 6 May there were, on average, 2.8 potatoes/m^2 which comprised 0.7 large (20 cm high with 5-10 stems), 1.5 medium-sized (10 cm high with 2-5 stems) and 0.6 small (just emerging with only 1 stem visible) plants. There were no significant differences between the plots. On 6 May there were, on average, 9.4 oilseed rape plants/m^2 which comprised 0.9 large (4 true leaves), 5.5 medium-sized (2 true leaves) and 3.0 small (cotyledon stage) plants. There were no significant differences between the plots.

Weed control

The effects of the first two herbicide treatment applications were recorded on 19 May, and the overall effects of the three applications were assessed on 9 June, and 31 July.

Potatoes

No treatment had completely controlled the potatoes when assessed on 19 May (Table 1). However, all treatments except **5** (two applications of Starane 2), **8** (two applications of Starane 2 + Totril), and **14** (two applications of Gesagard) had reduced ($P<0.05$) the vigour of large potatoes, and all had reduced the vigour of the small potatoes. The most effective reduction of potato vigour was achieved with treatments **6** (two applications of Atlas Somon + Totril), **7** (two applications of Atlas Somon + Fortrol) and **13** (two applications of Totril + Fortrol + Starane).

On 9 June, the vigour of the potatoes was reduced further. All treatments had reduced ($P<0.05$) both large and small potato vigour. The greatest reductions were with programmes **16** (two applications of Totril followed by Dosaflo) and **15** (two applications of Tribunil followed by Starane 2 + Totril). Other fairly effective programmes were **9** (two applications of Starane + Fortrol followed by Starane 2 + Totril) and **13** (two applications of Totril + Fortrol + Starane 2 followed by Starane 2 + Totril). On 31 July, potato vigour was reduced ($P<0.05$) by all treatments except **5**, **12** and **14**. The best treatments, overall, were **16** (two applications of Totril followed by Dosaflo) and **4** (two applications of Totril followed by Starane 2) followed by **9** (two applications of Starane 2 + Fortrol followed by Starane 2 + Totril).

Oilseed rape

When assessed on 19 May, all treatments had reduced ($P<0.05$) the numbers of oilseed rape plants compared with the untreated control (Table 2). Five treatments completely killed the oilseed rape. These were **3** and **16** (two applications of Totril), **8** (two applications of Starane 2 + Totril), **12** (two applications of Totril + Fortrol + Basagran), and **15** (two applications of Tribunil). Many other treatments also adequately suppressed the oilseed rape. Control of the oilseed rape plants was relatively poor for **5** and **10** (two applications of Starane 2 and two applications of Starane 2 + Dow Shield respectively).

At the end of the herbicide programmes, oilseed rape still survived on several plots. Control was particularly poor for treatment **10** (two applications of Starane 2 + Dow Shield followed by Starane 2 + Totril).

Table 1 Potato vigour scores on 19 May, 9 June and 31 July.

Herbicide programmes		Potato vigour score#				
		19 May		9 June		31 July
No.	Code	large	small	large	small	large
1.	Untreated	8.3	7.7	10.0	10.0	9.3
2.	Handweeded	0	0	0	0	0
3.	TTT	6.3	4.0	5.0	2.3	6.3
4.	TTS	6.3	3.7	4.0	1.7	3.0
5.	S x 2, S + T	7.3	4.7	6.0	3.0	7.3
6.	AS + T x 2, S + T	3.7	1.7	4.3	1.7	5.3
7.	AS + F x 2, S +T	4.7	2.0	4.3	1.7	5.7
8.	S + T x 2, S + T	7.0	4.3	5.7	3.0	5.0
9.	S + F x 2, S + T	5.7	3.7	3.7	1.0	4.0
10.	S + DS x 2, S + T	6.7	5.3	3.7	1.7	6.0
11.	T + F x 2, S + T	6.3	4.3	4.3	1.0	5.7
12.	T + F + B x 2, S + T	6.3	4.7	4.7	1.3	7.0
13.	T + F + S x 2, S + T	4.7	2.3	3.7	1.0	5.3
14.	G x 2, S + T	7.3	6.0	7.0	4.7	7.0
15.	Tr x 2, S + T	5.7	3.0	3.3	0.3	5.0
16.	T x 2, D	6.7	4.7	1.7	0	2.3
SED (46 d.f.)		0.66	0.72	1.05	1.15	1.41
LSD (5%)		1.33	1.45	2.12	2.32	2.85
CV%		14.3	23.2	27.0	72.2	31.9

# 0 = dead
10 = healthy, vigorous, green foliage.

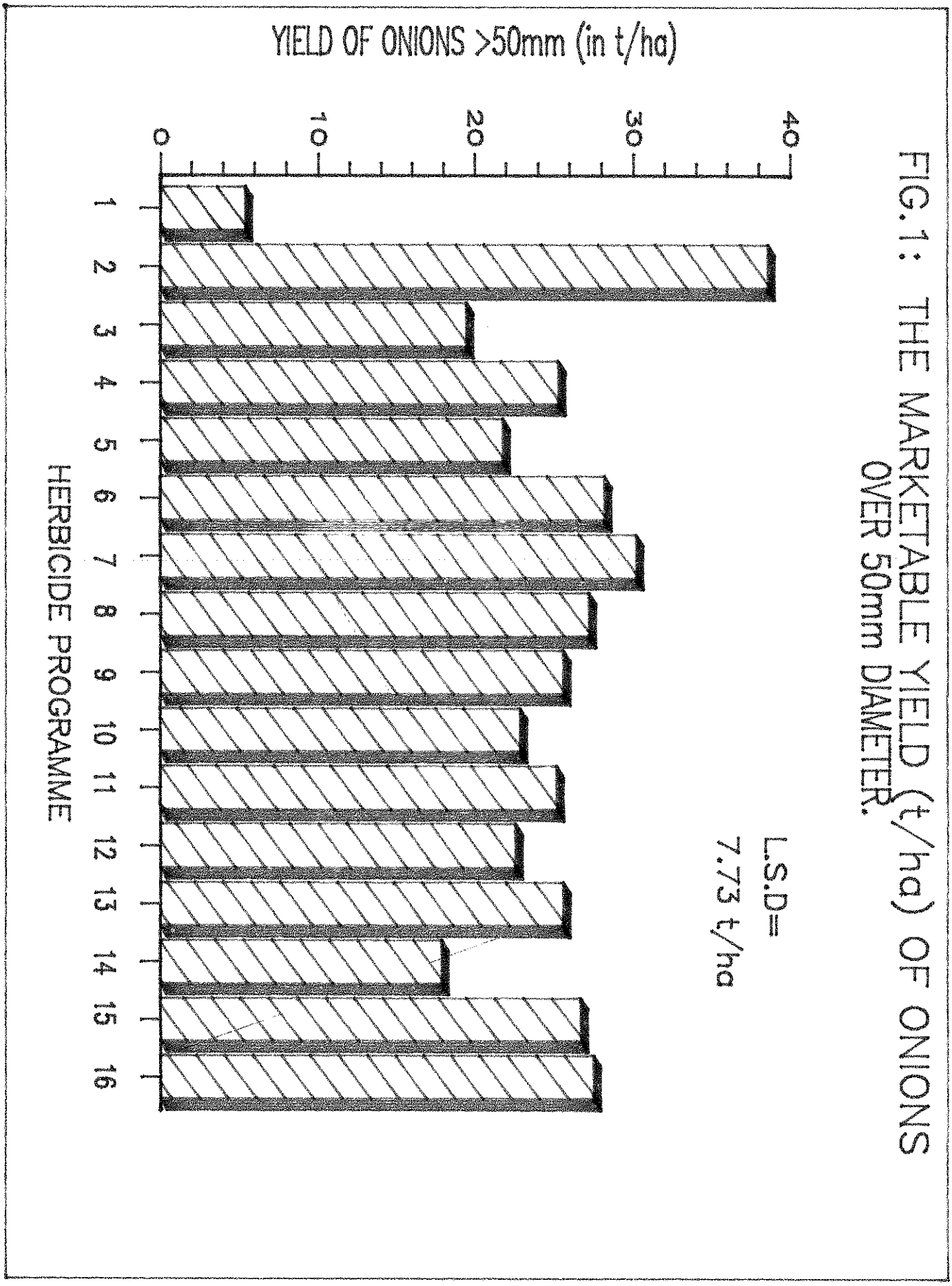

FIG.1: THE MARKETABLE YIELD (t/ha) OF ONIONS OVER 50mm DIAMETER.

L.S.D= 7.73 t/ha

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Table 2 Oilseed rape populations (plant/m²) on 19 and 27 May.

Herbicide programmes		Plant population (plants/m²)			
		19 May		27 May	
No.	Code	1*	2*	1#	2#
1.	Untreated	7.5	3.3	9.3	9.0
2.	Handweeded	0	0	4.0	4.0
3.	TTT	0	0	0	0
4.	TTS	0.8	0	0	0
5.	S x 2, S + T	4.4	2.0	3.0	0.7
6.	AS + T x 2, S + T	0.4	0	1.0	0
7.	AS + F x 2, S + T	1.6	0	2.3	0.7
8.	S + T x 2, S + T	0	0.3	0	0
9.	S + F x 2, S + T	2.4	0	2.7	1.0
10.	S + DS x 2, S + T	5.6	2.0	6.3	4.3
11.	T + F x 2, S + T	0.8	0	0.3	0
12.	T + F + B x 2, S + T	0	0	0	0
13.	T + F + S x 2, S + T	0.4	0	0	0
14.	G x 2, S + T	2.8	1.6	1.0	0
15.	Tr x 2, S + T	0	0	0	0
16.	T x 2, D	0	0	0	0
SED (46 d.f.)		0.69	0.75	1.04	0.78
LSD (5%)		1.39	1.51	2.09	1.56
CV%		68.4	225	92	111

* 1 = plants from first sowing date, with at least one true leaf.
2 = plants from second sowing date, with cotyledons only.
\# 1 = plants from first two sowings, with at least one rough leaf.
2 = plnats from third sowing, just emerging.

Other broad-leaved weeds

On 7 May, prior to the first treatment application, there were very few broad-leaved weeds on the trial. The mean weed cover was 2.2 per cent, with no significant differences between the plots. The main weeds were hempnettle, cleavers, mayweed, redshank, black bindweed and knotgrass.

The weed control scores are shown in Table 3. After the first two herbicide applications all treatments were better ($P<0.05$) than the untreated control. When assessed on 15 June, at the end of the

treatment schedules, weed control was better on all plots except the hand-weeded control and treatment **14** (two applications of Gesagard followed by Starane 2 + Totril).

The control of weeds was recorded on 31 July, after further applications of herbicides over the whole trial. Weed control was good on all treatments except **12** (two applications of Totril + Fortrol + Basagran followed by Starane 2 + Totril). A list of weeds present at the end of each treatment schedule is given in Appendix IV.

Table 3 Other broad-leaved weed control scores on 19 May, 15 June and 31 July.

Herbicide programmes		Weed control score #		
		19 May	15 June	31 July
No.	Code			
1.	Untreated	4.3	4.0	2.3
2.	Hand-weeded	9.0	5.3	10.0
3.	TTT	8.0	10.0	7.3
4.	TTS	8.0	10.0	10.0
5.	S x 2, S + T	7.3	9.3	8.0
6.	AS + T x 2, S + T	9.0	9.7	8.3
7.	AS + F x 2, S + T	9.0	9.7	8.3
8.	S + T x 2, S + T	8.7	9.3	9.0
9.	S + F x 2, S + T	8.7	9.0	10.0
10.	S + DS x 2, S + T	7.0	9.0	8.7
11.	T + F x 2, S + T	8.7	9.7	8.3
12.	T + F + B x 2, S + T	9.0	9.7	6.7
13.	T + F + S x 2, S + T	9.0	9.7	9.0
14.	G x 2, S + T	7.7	6.7	8.0
15.	Tr x 2, S + T	8.0	9.7	7.7
16.	T x 2, D	8.0	10.0	8.7
SED (46 d.f.)		0.64	1.57	1.54
LSD (5%)		1.29	3.17	3.11
CV%		9.5	21.1	93.7

0 = weedy 10 = weed free.

Crop vigour

The onions were assessed on 6 May, when all plots appeared similarly vigorous with plants at the late post crook to first true leaf stage. The scores for crop vigour following the herbicide programmes are shown in Table 4.

Table 4 Onion vigour scores on 15 and 19 May, on 9 and 15 June and on 31 July.

Herbicide programmes		Onion vigour score#				
No.	Code	15 May+	19 May	9 June	15 June	31 July
1.	Untreated	5.0	7.3	3.0	3.3	3.0
2.	Hand-weeded	5.3	6.7	8.7	9.0	7.7
3.	TTT	4.7	7.0	7.7	7.3	6.3
4.	TTS	5.0	7.3	8.0	8.0	6.7
5.	S x 2, S + T	4.7	6.7	7.0	7.7	6.3
6.	AS + T x 2, S + T	3.3	6.7	7.7	7.7	6.7
7.	AS + F x 2, S + T	4.7	7.0	8.0	8.3	7.3
8.	S + T x 2, S + T	4.3	6.7	8.3	7.7	6.3
9.	S + F x 2, S + T	4.7	6.7	8.3	8.3	6.3
10.	S + DS x 2, S + T	5.0	6.7	8.0	8.7	6.0
11.	T + F x 2, S + T	4.7	7.0	7.3	7.7	6.7
12.	T + F + B x 2, S + T	4.7	6.7	7.3	7.3	7.0
13.	T + F + S x 2, S + T	4.7	6.3	7.7	7.7	6.7
14.	G x 2, S + T	4.7	7.0	7.0	7.3	6.0
15.	Tr x 2, S + T	4.3	6.7	7.3	7.3	7.0
16.	T x 2, D	5.7	7.0	7.7	6.7	7.0
SED (46 d.f.)		0.49	0.50	1.02	0.81	0.66
LSD (5%)		1.00	1.01	2.06	1.64	1.34
CV%		13.3	9.2	17.5	13.3	12.4

# 0 = dead
10 = vigorous, healthy, green

+ before treatment application.

The effects of the first treatments on crop vigour were recorded on 15 May. The crop vigour was low, overall, due to wind damage and ground frosts in April and May (Appendix VI). All treatments gave a similar crop vigour score except **6** (Atlas Somon + Totril) which was lower ($P<0.05$). On 19 May, after the second treatments had been applied, there were no differences in vigour between the herbicide programmes. After the third treatment applications, the vigour scores were recorded on 9 June, when all treatments had a higher vigour score than the untreated control, but with no differences between the treatments. On 15 June, all treatments had a higher onion vigour score than the untreated control. Several treatments had lower ($P<0.5$) vigour scores than the hand-weeded control which were **3** (three applications of Totril), **12** (two applications of Totril + Fortrol + Basagran followed by Starane + Totril) **14** (two applications of Gesagard followed by Starane 2 + Totril), **15** (two applications of Tribunil followed by Starane 2 + Totril) and **16** (two applications of Totril followed by Dosaflo).

On 31 July several treatments had significantly ($P<0.05$) lower vigour than the hand-weeded control. These were treatments **3** (three applications of Totril), **5** (two applications of Starane 2 followed by Starane 2 + Totril), **8** (three applications of Starane 2 + Totril), **9** (two applications of Starane 2 + Fortrol followed by Starane 2 + Totril), **10** (two applications of Starane 2 + Dow Shield followed by Starane 2 + Totril) and **14** (two applications of Gesagard followed by Starane 2 + Totril).

Yield

The mean total yield of 35 t/ha was at around the average for most seasons. All herbicide programmes had higher ($P<0.001$) total and marketable yields (Table 5) than the untreated control. All treatments except **6** and **7** (where Atlas Somon was mixed with low rates of either Totril or Fortrol respectively) gave lower ($P<0.05$) total yields than the hand-weeded control. All programmes had a lower marketable yield of over 50 mm-sized bulbs when compared with the hand-weeded control (Table 5; Figure 1). Programmes **6** and **7**, and also **8** (three applications of Starane 2 + Totril), **15** (two applications of Tribunil followed by Starane 2 +

Totril) and 16 (two applications of Totril followed by Dosaflo) gave relatively high yields. Treatments 3 (three applications of Totril) and 14 (two applications of Gesagard followed by Starane 2 + Totril) gave relatively low yields.

The yields in individual size grades are shown in Appendix III.

Table 5 Plant population (plants/m²) at harvest, total yield (t/ha) and marketable yield (t/ha) of over 50 mm sized bulbs.

Herbicide programmes No.	Code	Plant population (plants/m²)	Total yield (t/ha)	Marketable yield over 50 mm (t/ha)
1.	Untreated	32	13.0	5.4
2.	Hand-weeded	51	47.2	38.6
3.	TTT	40	29.3	19.5
4.	TTS	45	35.9	25.3
5.	S x 2, S + T	49	34.6	21.8
6.	AS + T x , S + T	51	40.5	28.2
7.	AS + F x 2, S + T	44	40.4	30.2
8.	S + T x 2, S + T	48	39.1	27.2
9.	S + F x 2, S + T	44	35.3	25.6
10.	S + DS x 2, S + T	45	33.5	22.9
11.	T + F x 2, S + T	46	35.3	25.2
12.	T + F + B x 2, S + T	45	33.6	22.6
13.	T + F + S x 2, S + T	46	36.5	25.6
14.	G x 2, S + T	44	29.9	17.9
15.	Tr x 2, S + T	48	38.2	26.7
16.	T x 2, D	45	38.2	27.5
SED (22 d.f.)		4.27	3.55	3.73
LSD (5%)		8.6	7.36	7.73
CV%		11.3	12.4	18.7

Bulb quality

The bulbs were very firm (mean score 9.7) after curing. They had a very attractive appearance (8.9) and were quite dark brown (7.5). They had fairly good skin protection (6.8). The bulbs were flat-round in shape

(4.1) and reasonably uniform (6.5). There were no significant differences between the herbicide treatments.

Defective bulbs

There were very few defective or damaged bulbs comprising thicknecked bulbs (0.1%), rotten bulbs (0.1%) mechanically damaged bulbs (0.03%) and split bulbs (0.01%). There were no significant differences between the herbicide treatments.

Additional herbicide programmes

A further five herbicide programmes which did not form part of the contract, were evaluated. These programmes included the use of Totril, Fortrol, Starane 2 and Dow Shield in combination or in tank-mixtures. None of these programmes gave improved control of potatoes or oilseed rape compared with those listed. Three other programmes which appeared to reduce potato vigour were low dose cocktails of Totril + Fortrol + Manganese + Fusilade + Agral; mixtures which would be particularly pertinent to fenland onion growers. These treatment caused temporary loss in crop vigour but, by the end of July, they had similar vigour scores to the hand-weeded control.

Discussion

The planted potatoes competed with the onions from their early first true leaf stage. At that time, it was considered unlikely that any herbicide programme would completely kill the large and vigorous potato stems.

Several programmes effectively suppressed early potato growth to prevent severe competition with the onions, but for all treatments except **16** (two applications of Totril followed by Dosaflo), and to a lesser extent **15** (two applications of Tribunil followed by Starane 2 + Totril), potatoes would have had to be removed to allow mechanical harvesting; neither Dosaflo nor Tribunil are currently approved for use on onions.

The best programmes, using approved products, were **9** (three applications of Starane 2 + Totril) and **13** (two applications of Totril + Fortrol + Starane 2 followed by Starane 2 + Totril), although both used three low rate applications of Starane 2 when only two are currently permitted for "off-label" use.

The use of Atlas Somon in tank-mix with either Totril (**6**) or Fortrol (**7**) for early suppression of potatoes proved promising. Frequent repeated low-rate applications of tank-mixes including this product may allow continued suppression of potato growth.

Most programmes, except **10** (two applications of Starane 2 + Dow Shield followed by Starane 2 + Totril) adequately controlled oilseed rape, such that this weed did not appear to be a real problem. However, it is accepted that repeated flushes of the weed may prove difficult to control, unless herbicide applications are timed specifically for its control.

All other broad-leaved and grass weeds, except annual meadow-grass, were effectively controlled by all herbicide programmes.

All treatments reduced the total and marketable yield of onions compared with the hand-weeded control. In this experiment, it was not entirely clear to what extent yield loss was due to weed competition or to herbicide damage of young onion plants. The least reduction was achieved using programmes **6** (two applications of Atlas Somon + Totril followed by Starane 2 + Totril), **7** (two applications of Atlas Somon + Fortrol followed by Starane 2 + Totril), **8** (three applications of Starane 2 + Totril), **15** (two applications of Tribunil followed by Starane 2 + Totril) and **16** (two applications of Totril followed by Dosaflo).

The farm crop standard, programme **3**, (three fairly high rates of Totril alone) caused a significant yield reduction when compared with safer herbicide programmes.

Overall, the best programmes were **15** and **16** (non-approved) in terms of good potato, rape and general weed control with minimal yield loss, and **6** and **7** of the approved programmes, which adequately suppressed (but not controlled) early potato growth and controlled rape and other weeds with minimal yield loss.

Conclusions

1. All herbicide treatments reduced the vigour of planted potatoes compared with the untreated control.

2. The most effective control of potatoes was achieved using treatment **16**, a programme with Dosaflo, a chemical which is not currently approved. Some measure of effective suppression was also achieved with programmes **15** (which used the non-approved product Tribunil), **6** and **7** (which used early application of Atlas Somon in tank-mixes with Totril and Fortrol respectively), **9** (repeated applications of Starane 2 + Totril) and **13** (which used applications of Totril + Fortrol + Starane 2).

3. Good control of oilseed rape and other broad-leaved weeds was achieved by all programmes except **10** (where Starane 2 was mixed with Dow Shield) and to a lesser extent **5** (where Starane 2 was used alone at the early first leaf stage).

4. The best programmes were **16** followed by **15** which used the non-approved products Dosaflo and Tribunil respectively.

5. The best programmes which used approved products were **6** (two applications of Atlas Somon + Totril followed by Starane 2 + Totril); **7** (two applications of Atlas Somon + Fortrol followed by Starane 2 + Totril) and **9** (two applications of Starane 2 + Fortrol followed by Starane 2 + Totril).

Acknowledgment

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Recommendations

1. A further evaluation of sequences of tank-mixes of the most effective products against potatoes and oilseed rape should be made.

2. An off-label approval should be sought for the use of Dosaflo from the second true leaf stage of crops grown on organic soils.

3. An evaluation of low dose tank-mixed products against annual meadow-grass could be considered.

4. The use of low dose tank-mixtures of "cocktails" of products such as manganese sulphate and Fusilade 5 with Totril and Fortrol, which could allow more efficient spray applications on fenland onions, should be evaluated further.

Appendix I

Management of the trial site

Previous cropping	1991	sugar beet
	1990	winter wheat
	1989	winter wheat

Crop diary

Cultivations	24 December	ploughed and furrow pressed
	20 February	power harrowed
	20 February	drilled with Stanhay Webb Mark II drill
	10 March	plant potatoes cv. Maris piper
	1 April	sow oilseed rape
	24 April	sow oilseed rape
	9 May	hand-weeded control plants
	19 May	sow oilseed rape
Herbicides	16 March	4.32 kg/ha ai propachlor + 2.24 kg/ha ai chlorpropham + 0.6 kg/ha ai paraquat as 9 l/ha cp Ramrod Flo + 5.6 l/ha cp CIPC 40 + 3 l/ha cp Gramoxone in 600 l/ha water.
	11 April	0.45 kg/ha ai chlorbufam + 0.56 kg/ha ai chloridazon as 2.25 kg/ha cp Alicep in 450 l/ha water.
	22 April	Alicep as above
	7 May	first application treatments applied
	15 May	second application treatments applied
	22 May	third application treatments applied
	18 June	1.11 kg/ha ai ioxynil + 0.70 kg/ha ai cyanazine as 0.5 l/ha Totril + 1.4 l/ha Fortrol in 400 l/ha water.
Fungicides	20 February	benomyl + thiram seed treatments
	23 July	1 kg/ha metalaxyl + 1.5 kg/ha ai chlorothalonil as 2 l/ha cp Folio in 200 l/ha water.
Insecticides	20 February	2.8 kg/ha ai aldicarb as 28 kg/ha cp Temik (granules)
	23 June	0.96 kg/ha ai chlorpyrifos as 2 l/ha cp Dursban 4 in 1000 l/ha water (cutworm control)
Fertiliser	23 December	109 kg/ha Triple Superphosphate + 133 kg/ha muriate of potash
	25 April	40 kg/ha N
	1 June	40 kg/ha N
Trace elements	15 May	9 kg/ha $MnSO_4$ in 280 l/ha water
	9 June	manganese as above
	7 July	manganese as above
Irrigation	2 July	25 mm

Sprout Suppressant	14 August	3.1 kg/ha ai maleic hydrazide as 17 l/ha cp Maleic Hydrazide (18%) in 500 l/ha water
Harvest	1 September	
Graded out of store	28 September	

Appendix II

Active ingredients of commercial products used in the trial.

Product	Active ingredient
Atlas Somon	96% w/w sodium monochloroacetate
Basagran	480 g/l bentazone
Dosaflo	500 g/l metoxuron
Dow Shield	200 g/l clopyralid
Fortrol	500 g/l cyanazine
Gesagard	50% w/w prometryn
Starane 2	200 g/l fluroxypyr
Totril	220 g/l ioxynil
Tribunil	70% w/w methabenzthiazuron

Appendix III

Marketable yield (t/ha) in size grades.

Herbicide programmes		Marketable yield t/ha			
		40-50 mm	50-60 mm	60-80 mm	>40 mm
No.	Code				
1.	Untreated	4.6	3.8	1.4	10.0
2.	Hand-weeded	7.8	23.3	15.3	46.4
3.	TTT	8.0	10.7	8.7	27.4
4.	TTS	8.9	16.6	8.5	34.2
5.	S x 2, S + T	10.2	14.9	7.0	32.1
6.	AS + T x 2, S + T	10.9	19.4	8.8	39.1
7.	AS + F x 2, S + T	9.4	20.1	10.1	39.6
8.	S + T x 2, S + T	10.1	17.4	9.8	37.3
9.	S + F x 2, S + T	8.1	15.7	9.9	33.7
10.	S + DS x 2, S + T	8.7	14.1	8.8	31.6
11.	T + F x 2, S + T	8.4	14.7	10.2	33.5
12.	T + F + B x 2, S + T	9.5	15.8	6.8	32.1
13.	T + F + S x 2, S + T	9.1	15.3	10.2	34.7
14.	G x 2, S + T	9.4	12.5	5.4	27.2
15.	Tr x 2, S + T	10.2	19.1	7.6	36.9
16.	T x 2, D	9.1	16.9	10.6	36.6
SED (22 d.f.)		1.37	2.34	2.99	3.92
LSD (5%)		2.85	4.84	6.2	8.13
CV%		18.9	18.3	34.4	14.4

Appendix IV

Weeds present on 9 June.

Herbicide programmes		Weeds present
No.	Code	
1.	Untreated	Cleavers, Mayweed, Hempnettle
2.	Hand-weeded	-
3.	TTT	None
4.	TTS	None
5.	S X 2, S + T	Annual meadow-grass
6.	AS + T x 2, S + T	Annual meadow-grass
7.	AS + F x 2, S + T	Annual meadow-grass
8.	S + T x 2, S + T	Annual meadow-grass
9.	S + F x 2, S + T	None
10.	S + DS x 2, S + T	Annual meadow-grass, mayweed
11.	T + F x 2, S + T	Annual meadow-grass
12.	T + F + B x 2, S + T	None
13.	T + F + S x 2, S + T	Annual meadow-grass
14.	G x 2, S + T	Cleaver, mayweed
15.	Tr x 2, S + T	Cleaver, Annual meadow-grass
16.	T x 2, D	Annual meadow-grass

Appendix V

Weather conditions at spraying.

7 May	Fairly calm at time of spraying, then wind rapidly increased. Warm day with 10.7 hours of sunshine.
8 May	Fairly dull windy cold day with 5.0 hours of sunshine.
15 May	Intermittent slight rain after spraying. Calm, dull morning with 6.4 hours of sunshine in the afternoon. Warm.
16 May	Cool breezy day with 14.0 hours of sunshine.
22 May	Warm bright fairly calm day with 11.9 hours of sunshine.
23 May	Very warm day with 9.6 hours of sunshine. Very breezy later on.
18 June	Cool breezy day. Cloudy in the morning with 6.2 hours of sunshine later on.
19 June	Cold windy day with only 3.7 hours of sunshine. Rain later in day.

Appendix VI

Weather records 1992.

	TEMPERATURES (°C)						DAILY SUNSHINE (HOURS)		RAINFALL (mm)	
	EXTREMES			ACCUMULATED DAY DEGREES ABOVE 6°C		MEAN SOIL TEMP				
	AIR		GRASS				CURRENT YEAR	25 YEAR MEAN	CURRENT YEAR	25 YEAR MEAN
	Max.	Min.	Min.	CURRENT YEAR	25 YEAR MEAN	AT 10 cm				
JAN	12.4	-5.6	-10.4	24	24	3.4	1.8	1.7	48.8	42.1
FEB	15.0	-3.4	-5.4	24	20	4.2	2.0	2.4	9.6	30.4
MAR	16.4	-0.8	-4.2	72	77	6.5	2.2	3.2	9.5	41.1
APR	17.9	-0.7	-5.7	116	129	8.5	4.1	4.7	39.0	37.6
MAY	27.7	1.3	-1.2	262	173	14.8	8.6	6.1	48.6	48.0
JUN	30.0	5.1	2.0	313	257	18.2	6.8	6.3	26.2	51.7
JUL	27.7	7.5	2.6	357	329	18.4	5.3	6.0	87.5	43.5
AUG	25.8	5.6	1.4	333	327	16.9	5.8	6.3	66.4	49.2
SEP	24.0	2.8	1.0	249	255	13.2	4.6	4.7	76.3	39.8
TOTAL MAR-AUG			1453	1292				277.2	271.1	

Notes: For the purposes of this table:

1. Readings taken at 0900 hours GMT.
2. A temperature of at least 6°C (42°F) is normally considered necessary for plant growth. Accumulated temperatures (day degrees) above 6°C are a measure of plant growth during the month.